AUTOMATED CAGE CLEANING APPARATUS AND METHOD

TECHNICAL FIELD

The present invention relates to an improved apparatus and method for cleaning the cages of laboratory animals.

BACKGROUND OF THE INVENTION

A conventional cage system for holding small laboratory animals is typically a three piece assembly having a clear plastic bottom, a grill for holding food and water, and a lid that attaches to the bottom and holds the grill in place. Additionally, a suitable bedding material, such as cedar shavings, is added to the bottom portion of the cage assembly to absorb animal waste and spilled food.

While in use the bedding becomes soiled, thereby necessitating the need for frequent cleaning of the cages. The cleaning process requires disassembly of the cage, removal of the soiled bedding from the bottom portion, washing, and drying the cage elements. Furthermore, upon completion of the aforementioned steps, clean bedding is added to the cage.

Robotic arms are known to assist laboratory personnel with this process. Currently, after the cages are disassembled, robotic arms remove the soiled cage bottoms

from a cart, invert the cage bottoms to thereby empty the contents (soiled bedding material), and place the empty/soiled cage bottoms in an appropriate position on a conveyer. The conveyer then advances the cage bottoms through a chamber or tunnel wash system, wherein the cage bottoms are cleaned by a suitable process, usually involving high pressure streaming water. Furthermore, a drying process is typically accomplished by subjecting the cleaned, yet wet cage bottoms to high velocity heated air. The other cage components, such as the grill and lid, may be cleaned in a similar manner.

Upon completion of the cleaning process, an automated device, such as an additional robotic arm, removes the cage bottoms from the conveyer and adds clean bedding. The cages are then reassembled and stacked on a cart where they may be returned to service.

Due to the extreme force of the streaming water required to clean the cage bottoms, the high velocity air required for drying, and the transfer of components between conveyers, the cage bottoms become skewed on the conveyer. The unpredictable arrangement of the skewed cage bottoms complicates automated removal of the cage bottoms from the conveyer. Robotic arms currently require the cage bottoms to be in a specific predetermined location. Because of the turbulent conditions of the process described above, the robotic arm can not efficiently remove the cage bottoms from the conveyer.

Additionally, robotic arms currently used in cage cleaning systems have bases that are fixedly mounted to the ground. Generally, the base of a first robotic arm is fixedly mounted to the ground in an area designated for receiving the soiled cage components, and the base of a second robotic arm is fixedly mounted to the ground in an area

designated for removing and assembling cages that have proceeded through the cleaning process. Because the base of the robotic arm is fixedly mounted to the ground, the area serviced by the robotic arm is limited to the area about the base. Furthermore, this configuration strictly limits the positioning of equipment accessed by the robotic arm, and thereby limits options in designing cage cleaning facilities.

Therefore, what is needed in the art is a cage cleaning apparatus and method that serves to reduce the repetitive steps associated with loading and unloading cage components on tunnel type cage washing systems.

Furthermore, what is needed in the art is an apparatus and method for cleaning cages that serves to limit human exposure to potentially harmful substances.

Moreover, what is needed in the art is an apparatus and method of cleaning cages that addresses the problems associated with the handling of skewed cage bottoms exiting the tunnel wash system.

Even further, what is needed in the art is an apparatus and method for cleaning cage components that utilizes a robotic arm that is more versatile and can service a greater area.

SUMMARY OF THE INVENTION

In order to overcome the above stated problems, the present invention provides an automated cage cleaning apparatus and method that reduces repetitive steps and limits human exposure to potentially harmful substances. Furthermore, the cage cleaning system of the present invention provides an apparatus and method for detecting and

removing skewed cage bottoms from a conveyer. Moreover, the present invention comprises at least one robotic arm having a rail mounted non-stationary base, capable of being mounted on a floor, wall, ceiling, or in a pit. This unique configuration allows more flexibility in the design of cage cleaning facilities and provides a means for a single robotic arm to handle multiple processes.

The automated cage cleaning system of the present invention provides a means for receiving soiled cage bottoms, loading and unloading the cage bottoms onto conveyers entering and exiting tunnel washing equipment, adding clean bedding to the cage bottoms, and returning the clean cage bottoms to service. The present invention further comprises a pair of robotic arms, such as a soil side robot and a clean side robot. The soil side robot is utilized for removing the dirty cage bottoms from a cart, rack, pallet or fixtured conveyer emptying soiled bedding from the cage bottoms, and placing the cage bottoms on a conveyer leading to the tunnel washing equipment. The clean side robot is used to grip the clean cage bottoms, and place the cage bottoms on a cart, rack, clean pallet, or fixtured conveyer.

Additionally, the present invention comprises an optical arranger robot with vision processing for detecting and moving skewed cage bottoms from either a conveyorized bedding dispenser or conveying table to a re-grip station. From the re-grip station, the clean side robot places the cage bottoms on a rack, pallet, fixture, or any other device suitable for holding a plurality of cage bottoms.

The soiled and clean side robots of the present invention further comprise bases that are slidably mounted on a rail. This configuration provides the robots with an additional axis of movement, allowing more versatility in designing cage cleaning

facilities. The robots also comprise a vertical rail, substantially perpendicular to the base, and an arm segment extending outward, substantially perpendicular to said vertical rail. Attached to a distal end of the arm segment is a gripping means. The gripping means and arm segment are adapted to firmly grasp a plurality of cage bottoms, invert the cage bottoms, and move the cage bottoms to the next stage in the process.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become appreciated and be more readily understood by reference to the following detailed description of one embodiment of the invention in conjunction with the accompanying drawings, wherein:

FIG. 1 is a flow diagram of the automated cage cleaning apparatus and method of the present invention;

FIG. 2 is a perspective view of the soil side of the automated cage cleaning apparatus of the present invention;

FIG. 3 is a perspective view of the clean side of the automated cage cleaning apparatus of the present invention; and

Fig. 4 is a perspective view of the soil/clean side robotic arm of the automated cage cleaning apparatus of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to **Figs. 1-3**, a flow diagram and perspective views of the improved apparatus and method for cleaning animal cages are shown. The apparatus includes a pair of loading/unloading robots, referred to hereinafter as the soil side robot **11**, and the clean side robot **12**. Additionally, the apparatus further comprises optical arranger robot **19**. In operation, the soiled cage components arrive at the cleaning area on a component cart **13**, or any suitable device for transporting a plurality of soiled components. The cart further comprises at least one soiled component rack **14** holding soiled cage bottoms, wherein the rack of soiled cage bottoms is attachable to an in-feed conveyer **22**. Once the rack **14** is securely attached upon the in-feed conveyer **22**, it advances toward soil side robot **11**. The soil side robot **11** grasps a plurality of cage bottoms from the rack **14**, inverts the cage bottoms over a soiled bedding receptacle **28 (Fig. 1)**, or any device suitable for receiving the soiled bedding from the cage bottoms, and places the cage bottoms in an inverted fashion (open end facing down) on the tunnel washer conveyer **24** leading to the tunnel wash system **15,** such as, for example, a continuous driven belt tunnel washer. Once an appropriate number of soiled cage bottoms are received into the tunnel washing system **15**, the cage bottoms are washed and dried by an appropriate means. Upon completion of the wash/dry process, the clean cage bottoms **16** advance on the tunnel washer conveyer **24,** toward the clean conveyorized bedding dispenser **18**. Prior to reaching the conveyorized clean bedding dispenser **18**, the cleaned cage bottoms **16** drop from the tunnel washer conveyer **24** to an inline conveyer **17**. The inline conveyer **17**

further comprises a receiving end **26** and a dispatch end **27**. The drop from the tunnel washer conveyer **24** to the inline conveyer **17** causes the clean cage bottoms **16** to invert (open end facing up) upon the receiving end **26** of the inline conveyer **17**. The reorientation of the clean cage bottoms **16** enables the cage bottoms **16** to receive clean bedding from the conveyorized clean bedding dispenser **18**. While a particular embodiment of the present invention utilizes an inline tunnel type conveyorized bedding dispenser, any suitable bedding dispenser may be used.

The turbulent conditions of the tunnel washing process, as well as the reorientation of the cage bottoms onto the inline conveyer, cause the cage bottoms to become skewed or disoriented. The system further comprises an optical arranger robot system for detecting skewed or disoriented cage bottoms on the inline conveyer **17**, and placing the cage bottoms in an orderly arrangement upon the cage bottom re-grip station **20**. Additionally, the optical arranger robot system can detect and reorient various cage components, such as wire baskets used to transport water bottles, or serve to dispense bedding into cage bottoms.

In operation, as the cage bottoms with clean bedding progress toward the dispatch end **27** of the inline conveyer **17**, they pass below an optical eye **25**. The optical eye **25** is mounted on an elevated stationary structure **23** above the inline conveyer **17**. The optical eye **25** is aptly positioned to view a predetermined area of the inline conveyer **17**. While **Fig. 3** shows an optical eye **25** mounted on an elevated stationary structure, additional embodiments are contemplated wherein the optical eye **25** may be mounted upon any suitable structure, such as, for example, the optical arranger robot **19**. In operation, the optical eye **25** transmits a video signal, presenting the position of the skewed cage

bottoms to an encoding device (not shown). The encoding device serves to convert the video signals received from the optical eye **25** into command signals suitable for guiding the optical arranger robot **19**. The optical arranger robot **19** may be mounted adjacent to the dispatch end **27** of the inline conveyer **17** and the cage bottom re-grip station **20** as illustrated in **Fig. 3**, or in any suitable position. As skewed cage bottoms progress toward the optical arranger robot **19**, the optical arranger robot **19** receives a command signal from the encoding device (not shown), providing the position of the cage bottoms, and enabling the optical arranger robot **19** to grasp the cage bottoms and place them on the cage bottom re-grip station **20**. From the cage bottom re-grip station **20** the cage bottoms are lifted by the clean side robot **12**, and stacked on an appropriate clean component rack **21** so that they may be returned to service. Alternatively, clean side robot **12** may transfer the cage bottoms from the re-grip station **20** directly to an out-feed conveyor **56**.

Furthermore, while the description above describes the cleaning of cage bottoms, the apparatus and method of the present invention may be used for cleaning various other cage components, such as grills for holding food and water and cage lids.

Referring now to **Fig. 4**, a perspective view of the loading/unloading robot is shown. The robot comprises a stationary mounting section **30** having an upper side **31** and a lower side **32**. The lower side **32** of the stationary mounting section **30** is generally in communication with the floor. The upper side **31** of the stationary mounting section **30** serves as a track to allow the arm assembly **40** to move along a horizontal axis (**Y** direction). The lower side **32** of the stationary mounting section **30** further comprises a plurality of leveling screw assemblies **34** and leveling screws **33,** thereby providing a means of assuring the stationary mounting section **30** is in stable communication with the

floor. While this particular embodiment illustrates the stationary mounting section **30** positioned for mounting to the floor, it is understood that the stationary mounting section **30** may be mounted to a wall, ceiling, or in a pit, if so desired. The upper side **31** of the stationary mounting section **30** comprises a track or a guideway **35**. Additionally, the stationary mounting section **30** further comprises a first side wall **36** and a second side wall **37**, each sidewall terminating at a respective upper guide **38** and **39**. The upper guides **38** and **39** are substantially perpendicular to the sidewalls **36** and **37** respectively, and extend outward therefrom.

The arm assembly **40** comprises an assembly carriage plate **41**, a vertical rail **42**, and an arm section **43**. The carriage plate **41** serves as the pedestal for the arm assembly **40**, and is in slidable communication with the stationary mounting section **30**. More particularly, the carriage plate **41** further comprises a carriage plate upper surface **44** and a carriage plate lower surface **45**. The carriage plate lower surface **45** has a plurality of pillow blocks **46** extending downward therefrom. The pillow blocks **46** each comprise a pillow block inner wall **47** having a groove **48** and bearing (not shown). The grooves **48** are adapted to receive the upper guides **38** and **39**, so that the carriage plate **41** is in slidable communication with the stationary mounting section **30**. Furthermore, the carriage plate **41** comprises a means for receiving the pneumatic and power lines necessary to control the arm assembly **40**. In the illustrated embodiment of the present invention a flexible cable tray **29** is used to provide the electronic and pneumatic connections needed to operate the arm assembly **40**.

In operation, the carriage plate **41** is propelled along the base **30**, in the **Y** direction, via a rack and pinion system (not shown). The rack runs the length of the track

between the sidewalls **36** and **37**, and below the carriage plate **41**. The lower surface **45** of the carriage plate **41** further comprises a servo motor with a pinion (not shown), wherein said pinion engages said rack to thereby propel the carriage plate **41** along the stationary mounting section **30**.

Furthermore, the carriage plate **41** further comprises a carriage plate turret assembly **51.** Vertical rail **42** extends in the **Z** direction, wherein the vertical rail **42** is rotatable about said carriage plate **41**. Additionally, vertical rail **42** serves to provide vertical lift for the arm section **43**.

The arm section **43** comprises a vertical coupler **54**, having a vertical coupler turret **55** attached thereto. Extending outward from said vertical coupler turret **55** is the grasping arm **52**. The grasping arm **52** comprises a rectangular frame **53** having a pair of padded gripper clamping bars **49** and **50** and pneumatic cylinders (not shown) for opening and closing the padded gripper clamping bars **49** and **50**. In operation, upon actuation of the pneumatic cylinders (not shown), a bank of cage bottoms or wire baskets are clamped between the padded gripper clamping bars **49** and **50**. Additionally, when used in conjunction with the soil side robot **11**, the vertical coupler turret **45** serves to rotate the grasping arm **52** (**B** direction), providing a means for removing soiled bedding from the cage, as well as reorientation of cages prior to placement on tunnel washer conveyer **24**.

The embodiments described are chosen to provide an illustration of principles of the invention and its practical application to enable thereby one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. Therefore, the foregoing description is to be

considered exemplary, rather than limiting, and the true scope of the invention is that described in the following claims.